



KING COUNTY  
Combined Sewer Overflow  
Water Quality Assessment for the  
Duwamish River and Elliott Bay



S U M M A R Y



KING COUNTY  
Department of Natural Resources

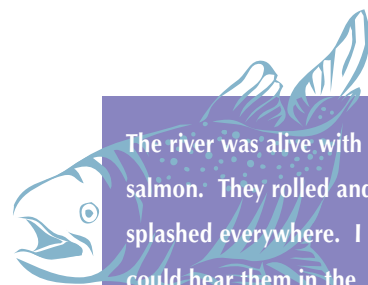
## The Duwamish Estuary: Yesterday and Today

Why don't we see a variety of fish and wildlife in the Duwamish River and Elliott Bay in Seattle today? The answer is complicated. Much is uncertain. But one thing we know for sure. Our activities have dramatically changed the water bodies in the area.

Over the past 100 years, we've changed the shape, the location, and the physical features of Elliott Bay and the Duwamish River by filling in wetlands, dredging the bottom of the water bodies for easier navigation, building houses and businesses along shorelines, and diverting or eliminating streams and rivers that flow into these waterbodies. And we've changed the quality of the water that remains in these water bodies. Past industrial practices, which are no longer in use, have left a legacy of pollution in the sediments. Today, human waste, animal waste, and the chemicals from the cars we drive, the

products we use in our households and businesses, and the crops we grow eventually find their way into our water bodies through sewers, leaky septic tanks, and stormwater runoff.

The Duwamish River and Elliott Bay are considered an estuary – a place where fresh-water and marine waters mingle. Estuaries support an abundance of life. Young salmon stay in the Elliott Bay-Duwamish River estuary for a while in order to eat and build up strength before moving into open marine water; perch, rockfish, sole, shrimp, crab, and mussels live there year round; spotted sand-



The river was alive with salmon. They rolled and splashed everywhere. I could hear them in the fog, and some I could see, huge shadows that climbed the air and slipped back into the water so close to the boat I could have touched them.

*Richard Hugo,  
The Real West  
Marginal Way, 1986*

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## Thank You

King County would like to express its appreciation to staff and members of the Combined Sewer Overflow Water Quality Assessment Stakeholder Committee, the Water Environment Research Foundation Peer Review Panel, Boeing, the Washington State Department of Fisheries, and the National Marine Fisheries Service for all their hard work and help on this project.

## COVER PHOTOS

Top: Elliott Bay  
Bottom: Duwamish River

Produced by the King County  
Department of Natural Resources  
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King County Water Quality Planner  
Design: Betty Hageman Graphic Design

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puget, bald eagle, great blue heron, and river otters feed and live in the area; and people use the area for activities such as fishing, shipping, airplane construction, boating, swimming, SCUBA diving, bird watching, and windsurfing.

Due to human activities, the amount of flow and the quality of the water in this estuary have diminished significantly since the mid-1800s. As a result, fish and wildlife populations and our ability to use and enjoy the area have also diminished. For example, commercial harvesting of shellfish is no longer allowed in Elliott Bay. Over the past 25 years, King County, businesses, environmental groups, tribal governments, and other agencies have started to address these concerns by undertaking numerous pollution control efforts to improve water quality. However, pollutants from a variety of sources continue to degrade the estuary.

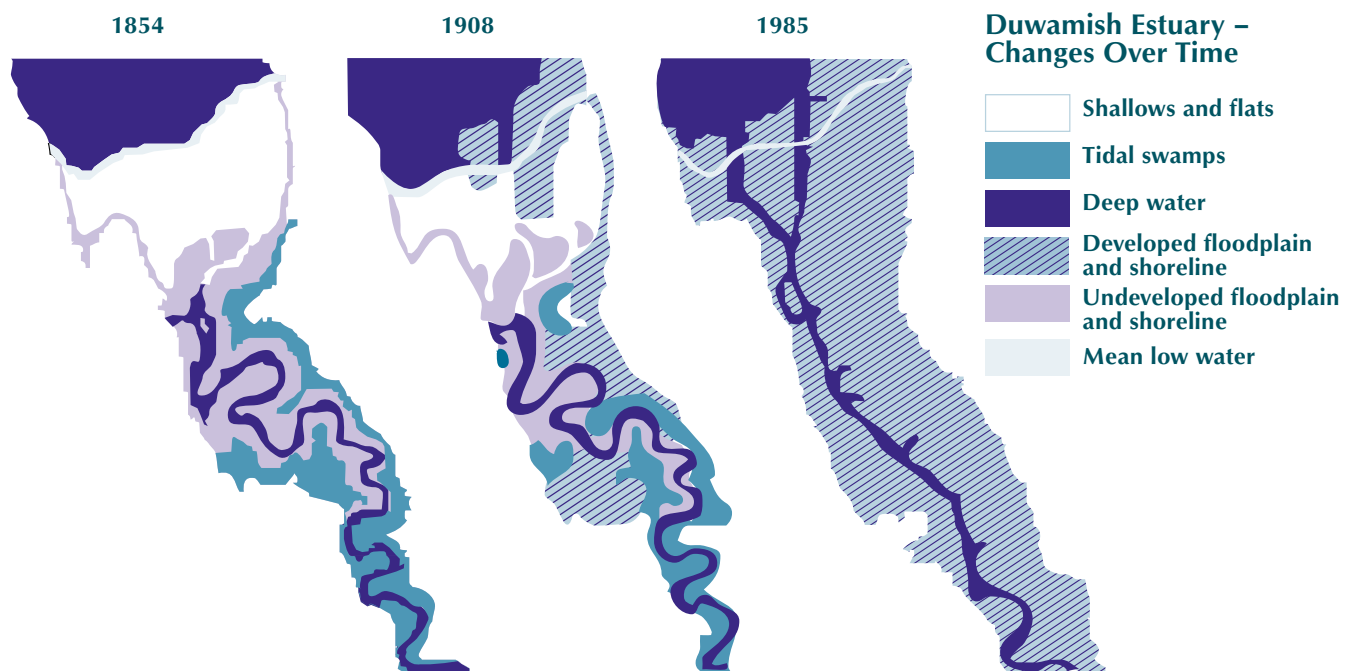
## King County CSO Water Quality Assessment

In a recent survey, you told King County that protecting and enhancing water quality in the region is a very high priority for you. We agree. Among the many sources of pollution in the estuary, the region's oldest sewers still discharge

untreated sewage mixed with stormwater to the estuary during heavy rainstorms. King County is responsible for planning to reduce these combined sewer overflows (CSOs) to meet the limits required by state regulations. As we were making these plans we still did not have a clear understanding of the dynamics of this complex estuary. To gain a better understanding of the estuary and the impacts of CSOs relative to other pollutant sources, we undertook an extensive study: *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (hereafter referred to as "the study"). Some of the questions we looked at included:

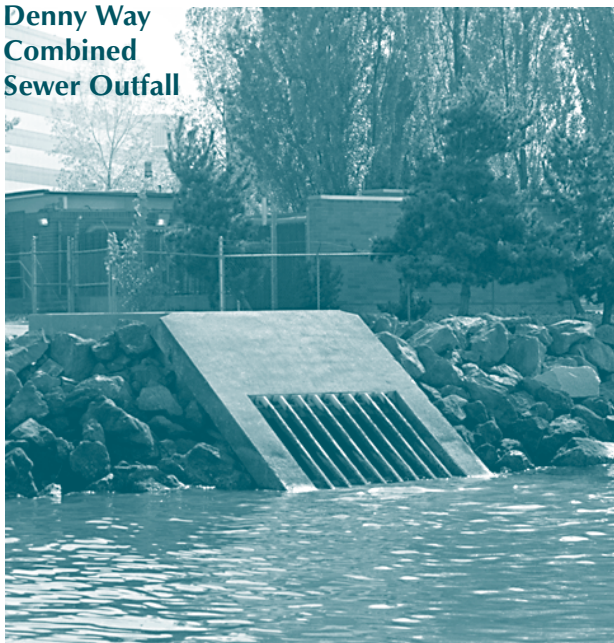
- What is the existing quality of the water and sediment?
- What are the flow patterns in the water and how are chemicals dispersed and/or ingested by aquatic life, wildlife, and humans?

*In portions of Seattle, as in many older cities, both sewage and stormwater travel to a treatment plant through the same pipes. During heavy or prolonged rains, pipes and treatment plants simply can't handle such large volumes. To protect the treatment plants and avoid sewer backups into homes and businesses, the "combined" sewers discharge their contents directly to the nearest body of water. These discharges are called combined sewer overflows (CSOs).*





## Denny Way Combined Sewer Outfall



- What are the health risks to humans and other creatures that come in contact with the estuary with CSOs and without CSOs?

*The study found clear evidence of potential health risks to aquatic life, wildlife, and people as the estuary exists today. These risks come from a variety of sources. Removing CSOs will reduce some risks, but others will remain.*

- Will the waters and sediment become cleaner and safer as a result of our CSO control efforts? If so, to what extent?

This study, along with other environmental programs and projects undertaken by King County and other agencies (e.g., the Green/Duwamish Watershed Forum and organizations developing fish recovery plans), provide more understanding of how CSO control projects complement other environmental control programs.

This added information will be reviewed to assess CSO projects and priorities. The following pages summarize how we conducted the study, what we found, and further actions recommended.

## Controlling CSOs

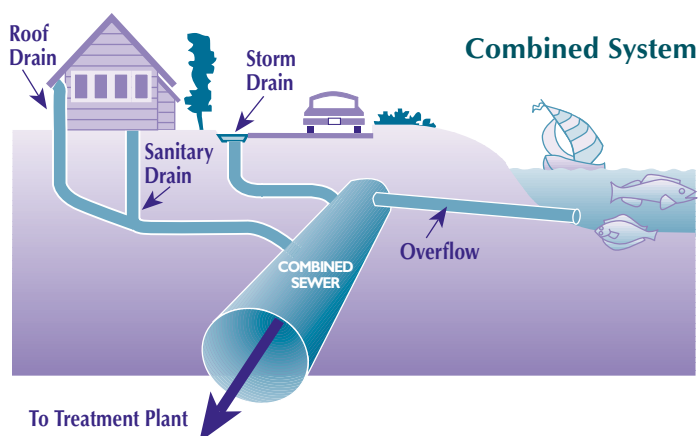
CSOs are one contributor to the pollution in the Elliott Bay-Duwamish River estuary. Even though the sewage being discharged is greatly diluted by stormwater, both CSOs and stormwater may be

harmful to public health and aquatic life because they carry chemicals and disease-causing pathogens. In order to protect water quality and human health, King County has been steadily working toward meeting the Washington State Department of Ecology (Ecology) standard that restricts combined sewer overflows to an average of one untreated discharge per year at each CSO location.

We have made tremendous progress in reducing CSOs. Over the past ten years, the volume of King County's CSO discharges has been reduced from 2.4 billion gallons to approximately 1.6 billion gallons on average per year. So far, 10 out of 37 CSO locations now meet the state standard. Completed CSO control projects have cost over \$60 million; another \$200 million is slated for current projects. The King County comprehensive sewer plan calls for bringing the remaining CSO locations to within the state standard by the year 2030, at an additional cost of approximately \$311 million.

The Elliott Bay-Duwamish River estuary includes 15 CSO locations, which discharge approximately 1.4 billion gallons of combined flow in each year of average rainfall. Considering that the entire King County system discharges a total of 1.6 billion

*Disease-causing pathogens such as bacteria and viruses are in the estuary. Sources include agricultural practices, stormwater runoff, failing septic systems, illegal sewer connections, and CSOs. Removing CSOs will reduce some of the risk of infection from human pathogens, most noticeably near the Denny Way CSO.*





"....It is true that today this area is industrialized, but it was not always that way. The Duwamish estuary was once a vibrant migratory route for salmon runs. Let us not think what we see today was always that way, or must be that way forever."

*Puget Sound Action Team Representative*

gallons per year, the 1.4 billion gallons discharged into the estuary represents a very large portion of the system's CSO volume. The frequency and volume of discharges in the estuary vary with each CSO location – ranging from 4 to 51 times and from 2 to 455 million gallons per year. The Denny Way CSO in Myrtle Edwards Park discharges the most frequently and has the largest volume of any of King County's CSOs. Projects are currently underway to control this CSO and another at Norfolk by 2003. As outlined in King County's comprehensive sewer plan, King County plans to construct several CSO control projects in the estuary. However, the CSO program will be reviewed every five years and potentially revised as additional studies are undertaken.

## Conducting The Study

The *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* was undertaken from 1996 through 1998. A key objective of the study was to consider the interests of the variety of people and groups who use the estuary. To achieve this objective, we sought a diversity of perspectives for the study.



"The River is a sacred river."

*Duwamish Valley Neighborhood Preservation Coalition Representative*

## Study Team

In addition to the core project team – consisting of scientists, planners, engineers, and other professionals – a stakeholder committee and a national peer review panel

lent their support to the study. The stakeholder committee – composed of representatives from local communities, businesses, environmental organizations, tribal governments, and

agencies – offered advice on technical matters, provided insight into issues, and shared the visions of their respective communities and organizations (the quotations included in this document reflect some of the values and visions of the stakeholder committee). Throughout the study, committee members donated large amounts of time and expertise in attending meetings and workshops, in gathering information, in reviewing and commenting on papers and reports, and in making recommendations.

The national peer review panel – composed of experts in the fields of risk assessment, CSO management, mathematical modeling, and aquatic toxicology – ensured that the study used the best possible science.

The panel was coordinated by the Water Environment Research Foundation Wet Weather Peer Review Program.

### Study Approach

The *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* consisted of three main tasks:

- **Collecting and analyzing samples.** We collected and analyzed over 2,000 samples to identify the type and level of pollutants in the water, sediment, and tissues (including samples from six of the CSO locations in the estuary).

*Benthic organisms are the small creatures that live in and on top of sediments. They are often the food for birds and fish.*

- **Computer modeling.** We developed and ran a computer model that could mathematically describe the water flow and the addition, removal, movement, and behavior of pollutants within the estuary. The model was used to estimate the levels of selected pollutants in the water and sediment of the estuary as they exist today and after removal of CSOs.

- **Risk Assessment.** We conducted a risk assessment to get an idea of whether and how these estimated levels of pollutants (chemicals, metals, disease causing organisms, and other water quality parameters) could harm the aquatic life, wildlife, and people that use the estuary.

From the community of animals that lives in the estuary, the project team and the Stakeholder Committee selected species that could represent the whole community. The study considered water-dwelling and sediment-dwelling organisms, as well as wildlife and people who may come in contact with the water or sediments. For water-dwelling organisms, salmon (chinook, coho, and chum) represented migrating fish and English sole represented fish that live in the estuary year-round. Sediment-dwelling organisms (benthos) were considered because their health and diversity are important both as indicators of the pollution in the sediment and as indicators of the health of other animals that feed on these organisms. The wildlife considered included river otters, spotted sandpipers, blue herons, and

*"We all have a right to expect a healthy environment both now and into the future. We, of today, do not have a right to destroy the resources and environment of the future." .... "We can't put things back to near perfect, but we can improve on what we are doing. It has been proven time and again, 'the healthier the environment, the healthier the economy.'"*

*Rainier Audubon Society Representative*

*The Elliott Bay-Duwamish River estuary is influenced by Puget Sound tides and currents and by freshwater flows from the Green River. By modeling this complex system, the study team was able to use computers to show what happens to pollutants entering the system from a variety of sources.*



## Sampling in the Duwamish River



bald eagles. Finally, the ways that people may come in contact with pollution were identified as fishing, swimming, SCUBA diving, windsurfing, and eating fish from the area.

A critical part of the study was to carefully consider which pollutants to analyze for and which aquatic life and wildlife and human activities to consider as representative of potential health risks. The list of pollutants covers chemicals and metals that can enter the estuary from CSOs, stormwater runoff, and other sources. The list also covers three of the microscopic organisms that may be found in human and animal wastes and that can serve as indicators of the risk of infection: fecal coliform (general indicator of the presence of pathogens), rotavirus (representative of human intestinal viruses), and Giardia (which may cause diarrhea in humans). Added to the list are non-pollutant water quality indicators and physical disturbances, such as the temperature and salinity of water and the scouring and deposition of sediment.

The study combined a great deal of information collected through sampling, analysis, and modeling to attempt to answer these questions:

- How often do aquatic life, wildlife, and people come in contact with pollutants?
- How are they exposed to the pollutants (such as through contact or ingestion of the sediments and water and/or by eating fish or shellfish)?
- How could they be harmed (such as decreased reproduction, death, cancer, and other non-cancer illnesses)?
- What is the toxicity of the pollutants (the level known to affect health)?

"This system is not a wilderness. It is an urban environment. However, the standards [for] its upkeep should not be lowered. The practical achievement of these standards may be limited by the historic burden which may take decades to eliminate."

*EPA Region 10/  
Risk Evaluation  
Representative*

*In a risk assessment, scientists estimate the likelihood of harm that could result from specific activities. The public and elected officials can use these estimates to help make informed decisions on how best to improve the quality of our waters.*

### Chemicals & Metals Studied

1,4-Dichlorobenzene  
4-Methylphenol  
Arsenic  
Benzo(a)anthracene  
Benzo(a)pyrene  
Benzo(b)fluoranthene  
Benzo(g,h,i)perylene  
Benzo(k)fluoranthene  
Bis(2-Ethylhexyl)phthalate  
Cadmium  
Chrysene  
Copper  
Dibenzo(a,h)anthracene  
Fluoranthene  
Indeno(1,2,3-cd)pyrene  
Lead  
Mercury  
Nickel  
Polycyclic Aromatic Hydrocarbons (PAHs)  
Phenanthrene

Pyrene  
Total Polychlorinated Biphenyls (PCBs)  
Tributyltin (TBT)  
Zinc

### Microbes Studied

Fecal coliforms  
Giardia  
Rotavirus

### Physical Changes Studied

Total Suspended Solids  
Scouring  
Sedimentation  
Displacement  
Salinity  
Dissolved Oxygen  
PH  
Temperature

## Key Findings

Major objectives of the study were to determine existing conditions of the Duwamish River and Elliott Bay with CSOs and the conditions of these water bodies if CSOs were eliminated. It was beyond the scope of this study to look at the specific impacts of other pollutant sources such as stormwater run-off, agricultural sources, and leaky septic tanks. More research would need to be undertaken to specifically categorize the impacts of each of the other sources.

The accompanying tables show the major study findings in terms of the health risks to people, wildlife, and aquatic life from living in and being in contact with water, sediment, and food in the estuary. The tables also include information on the effect that removing CSOs will have on reducing health risks. For most risks, removing CSOs will have little impact. However, removing CSOs will reduce risk of infection from human pathogens, most notably near the Denny Way CSO (which will be controlled by 2003). Removing CSOs will also reduce risks to sediment-dwelling organisms near the CSO discharges.

### Our Use of Chemicals Impacts Risk

#### ***1,4-dichlorobenzene***

Toilet deodorizing blocks, mothballs, fumigants, and chemical manufacturing

#### ***Arsenic***

Naturally occurring in Puget Sound water – other possible sources include pesticides, manufacturing, and the electronics industry

#### ***Bis(2-ethylhexyl) phthalate***

Plastics manufacturing – can be found in toys, vinyl upholstery, shower curtains, adhesives, and coatings

#### ***Copper***

Manufacture of metals products, drinking water pipes, fungicides, and preservatives

#### ***Lead***

Batteries, gasoline additives, paints, roofing materials, caulks, ammunition, and solder

#### ***Mercury***

Electrical equipment, dental fillings, and (in the past) used as a fungicide

#### ***Polycyclic Aromatic Hydrocarbons (PAHs)***

By-products of internal combustion engines, automobile fuels, lubricants, and other sources

#### ***Polychlorinated Biphenyls (PCBs)***

Coolants and lubricants in transformers, capacitors, and other electrical equipment

#### ***Tributyltin (TBT)***

Antifouling agent in marine paints, a wood and paper preservative, and sometimes found in disinfectants

#### ***Zinc***

Rust preventatives, dry cell batteries, pennies, and metal alloys



## Health Risks To Aquatic Life

### Risks Today With CSOs

**WATER-DWELLING ORGANISMS** (risk refers to growth, reproduction, and mortality)

**Chemicals:** Minimal potential risks from chemicals or other water quality indicators. Any potential risks are below Environmental Protection Agency (EPA) levels.

**SEDIMENT-DWELLING ORGANISMS** (risk refers to reduced biological diversity and increased numbers of pollution tolerant species)

**Chemicals:** Potential risks from several chemicals in sediments.

- Most important cause of potential risk from PCBs and TBT.
- Low risks from bis (2-ethylhexyl) phthalate, mercury, and PAHs.
- Low risks from 1,4-dichlorobenzene.

**Organic enrichment:** Localized increase in benthos that flourish in organic-enriched areas and decrease in benthos that are less tolerant of organic enrichment. Organic enrichment includes decomposing matter such as human waste, leaves, dead fish, bacteria, fecal coliforms, fats, oils, etc.

**Sedimentation and Scouring:** Localized areas of sedimentation and scouring that would affect the benthic community.

### Effect Of CSO Removal

*No predicted reductions in risks for water-dwelling organisms.*

*Some predicted reductions in risks to sediment-dwelling organisms near the CSO discharges. No predicted reductions elsewhere in the river and the bay.*

- No predicted reductions in risks from PCBs or TBT. These chemicals generally come from sources other than CSOs.
- No to slight predicted reductions in risks from bis(2ethylhexyl) phthalate, mercury and PAHs in sediment near CSOs.
- Predicted reduction in risk from 1,4-dichlorobenzene.

*Possible increase in the variety of benthic organisms near CSOs as the result of decrease in organic matter.*

*Possible reduction in impacts of localized scouring and sedimentation may be small compared to the overall scouring impacts of the river and sediment from other sources.*

## Health Risks to Wildlife

### Risks Today With CSOs

**Spotted sandpiper:** Apparent relatively high risks from chemicals in their food, particularly lead but also copper, PCBs, and zinc. These chemicals may effect behavior, growth, and reproduction in animals.

**River otter:** Some possibility that lead from food and sediments would be high enough to possibly impact reproduction. Also, an apparent risk associated with arsenic which could impact reproduction.

**Bald eagle and great blue heron:** A lower possibility that lead from food and sediment might be high enough to possibly impact reproduction.

### Effect Of CSO Removal

*No predicted reductions in risks to wildlife as other sources contribute the majority of the risk-related chemicals.*

## Health Risks to People

### Risks Today With CSOs

#### FROM EATING SEAFOOD

**Chemicals:** Potential risks, most notably from exposure to PCBs and arsenic. Risks from arsenic are about the same as for eating fish from Puget Sound sites we used as reference sites for this study.

##### Cancer risks from chemicals:

- Relatively high lifetime risk of developing cancer from exposure to arsenic and PCBs for people who eat seafood from the area every day (about 1 person in 1,000 to 1 person in 100, depending on the type of seafood).
- Lifetime cancer risk greater than 1 person in 1,000,000 for people who catch and eat seafood from the area on average about two times per month (a fairly common occurrence, according to our survey). [One chance in a million is a commonly used regulatory threshold for acceptable cancer risk.]
- Cancer risks caused by PCBs in sole are about 20 times higher in the Duwamish River than in Elliott Bay and nearly 10 times higher in Elliott Bay than in reference Puget Sound sites.

**Other risks from chemicals:** There are other risks from PCBs and arsenic for people who eat seafood from the river and bay every day. Examples include effects on the neurological system, immune system and skin.

**Pathogens:** Fecal coliform levels indicate potential risks of infection from shellfish consumption.

#### FROM ACTIVITIES

##### Chemicals:

- **Net fishing:** Potential lifetime cancer risks of about 1 person in 100,000 from arsenic and PCBs in sediments for people who net fish in the Duwamish River 90 times per year.
- **Swimming:** Potential lifetime cancer risks above 1 person in 1,000,000 from arsenic and PCBs in sediments for young children who swim 24 times per year at Duwamish Park in the Duwamish River and Duwamish Head in Elliott Bay.
- **Windsurfing and SCUBA diving:** Potential lifetime cancer risks are less than 1 person in 1,000,000 for people who windsurf in Elliott Bay or SCUBA dive at SeaCrest Park as frequently as 24 times a year.

##### Pathogens:

- Fecal coliform levels indicate potential risks of infection from direct exposure during fishing, swimming, windsurfing, and SCUBA diving.
- During CSO discharges, risks of infection from Giardia and viruses due to CSOs could be as high as 1 person in 100 during all activities studied. These risks of infection from CSOs decrease to less than 1 person in 1,000 within 6 hours after discharge.

### Effect Of CSO Removal

**No predicted reductions in risks for people from chemicals in seafood.**

- No predicted reductions in cancer risks because most PCBs and arsenic come from sources other than CSOs.
- No predicted reductions in cancer risks because most PCBs and arsenic come from sources other than CSOs.
- No predicted reductions in cancer risks because most PCBs and arsenic come from sources other than CSOs.

**No predicted reductions in risks of non-cancerous health effects because most PCBs and arsenic come from sources other than CSOs.**

**Potential risks of infection from shellfish consumption will decrease slightly, but risks will continue to exist because fecal coliforms also come from sources other than CSOs.**

- No predicted reductions in risks because most PCBs and arsenic come from sources other than CSOs.
- No predicted reductions in risks because most PCBs and arsenic come from sources other than CSOs.
- Health risks do not change because PCBs and arsenic come from sources other than CSOs.
- No predicted reductions in risks from fecal coliform concentrations because fecals also come from sources other than CSOs, except near the Denny Way CSO location where some risk reduction is predicted.
- Risks of infection from Giardia and viruses due to CSOs will be eliminated, but the level of risk from other sources remains unknown.

## Stakeholder Committee

### Conclusions And Recommendations

The Stakeholder Committee reviewed the study's findings and associated uncertainties, drew conclusions from their interpretations, and made recommendations. The Committee's most important interpretation of the findings is that the existing environmental quality of the area poses a serious problem. Four important conclusions emerged from this interpretation:

- Existing sediment quality and associated risks to people, wildlife, and aquatic life in the estuary are unacceptable.
- Levels of human pathogens and fecal coliforms in the estuary are unacceptable.
- Controlling CSOs according to the King County comprehensive sewer plan will improve some aspects of environmental quality.
- Even if CSOs are completely eliminated, overall environmental quality will continue to be unacceptable.

Following these conclusions, the major recommendation that emerged from the Stakeholder Committee is that a comprehensive regional program should be implemented to bring the river, its tributaries, and the bay to acceptable quality and risk levels. The Stakeholder Committee recommendations included:

- Complete the comprehensive regional program at the earliest possible date, but no later than 2030.
- Adopt an integrated approach that includes participation by multiple jurisdictions.
- Include CSO control and the following actions in the program:
  - Control stormwater and non-point (based on a wide variety of human activities) sources of contaminants
  - Restore habitat at some sites
  - Conduct public involvement and education programs
  - Remediate the sediment at some sites
  - Control permitted discharges
  - Periodically monitor the water quality to establish trends

- Maintain diligence in developing and implementing protective environmental standards

- Conduct additional water quality studies to further refine our understanding of risks as well as to develop, implement, and continually update the comprehensive control program.

### What's Next?

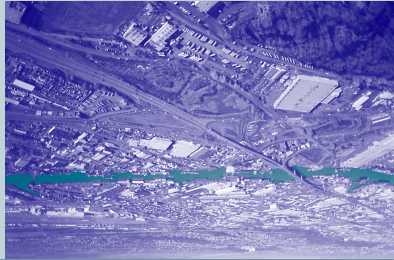
This study represents a major step in working toward creating an estuary that people, aquatic life, and wildlife can enjoy without unacceptable risks to their health. It is the first time that the entire area has been examined in such depth. The study helped to identify the extent of the problem today and with reduction of CSOs, but additional information must be gathered so that King County and other jurisdictions can start to implement broader solutions to the complex problems of the estuary. We need to learn more about the specific contributions of pollutants from various sources and the best ways for controlling these sources in a cost-effective manner. The computer model and information from the risk assessment will be used to support the development of future studies and projects.

King County is committed to protecting public health and the environment. Thus, King County's comprehensive sewer plan outlines wastewater projects to be constructed over the next 30 to 40 years. This study, along with other environmental programs and projects undertaken by King County and other agencies (e.g., the Green/Duwamish Watershed Forum and organizations developing fish recovery plans), provides a greater understanding of how CSO control projects complement other environmental control programs. CSO projects and priorities will be reassessed every five years as more information becomes available.

### For More Information

For more information or to schedule a presentation on this study, please contact **Sydney Munger, CSO WQA Project Manager**, at 206-296-1970 or e-mail at [sydney.munger@metrokc.gov](mailto:sydney.munger@metrokc.gov).

For copies of our documents, you can also visit our website at: <http://splash.metrokc.gov/wlr/waterres/wqa/wqpage.htm>



*What are the  
impacts of CSOs  
compared to other  
pollutant sources?*

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